

# Today's Energy Challenges, Tomorrow's Solutions

Electrons to Molecules: Building a New Foundation for Industrial Processes

**The future will be defined not only by the need for more resilient and accessible energy, but also by greater and more varied types of demand. As our population grows and urbanization increases, so will our demand on the world's energy resources.**

NREL is meeting this challenge head-on by focusing our expertise and resources on three research areas that will accelerate the transformation of traditional energy products, practices, and industries. This requires more than simply enabling low-cost renewable and low-carbon electricity generation. It also means moving toward two-way power flow and digitization, developing new methods to convert carbon molecules derived from today's fossil fuels and use them in new ways, and rethinking how products are designed and recycled for maximum material efficiency.

NREL is Transforming Energy—how we generate, consume, store, and distribute it. And we invite you to join us in that effort.

## Research Area: Electrons to Molecules

The vast majority of global goods and materials we use on a daily basis are manufactured from fossil fuel precursors—chemical building blocks strung together using combinations of heat, pressure, and chemical catalysis.

## Electrons to Molecules

Hybrid Approaches to CO<sub>2</sub> Reduction  
and Creating the Electron Foundry

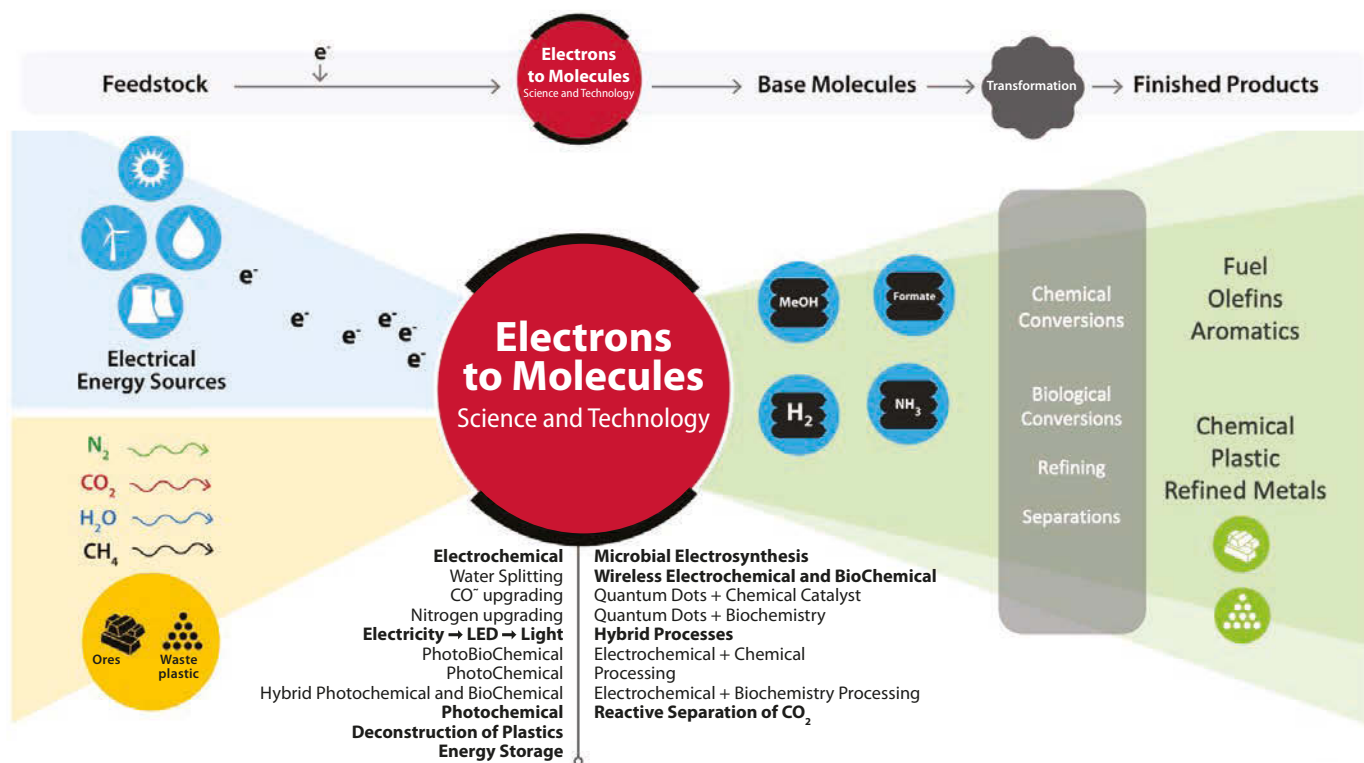
Reactive Carbon Capture  
and Conversion

Novel Electricity-Driven Processes  
for Industrial Manufacturing

NREL, along with energy industry partners, is exploring the use of renewable, affordable electricity as the driving force for the conversion of low-energy molecules—such as water and carbon dioxide (CO<sub>2</sub>)—to generate higher-value, higher-energy chemicals, materials, and fuels as end-use products or as a means toward energy storage.

Through this research, NREL and its partners are working together to rethink how common industrial manufacturing processes will respond to a world that desires low-carbon products and processes and has access to growing quantities of relatively inexpensive, green electricity.





## The Challenge

While several approaches for upgrading CO<sub>2</sub> to chemicals and fuels already exist, the ability to accomplish this in a cost-effective, low-carbon manner has proven elusive. Historically, our manufacturing system has been based on the conversion and manipulation of chemical bonds within fossil fuels to make products.

Chemical approaches using catalysis and bio-catalysis can transform a variety of feedstocks (starter materials) including carbon dioxide, biomass, and fossil fuels into the same products we use today—as well as future products with enhanced performance.

Industrial interest in CO<sub>2</sub> capture and conversion is growing; and when combined with low-cost, abundant, renewable electricity, it will provide new low-carbon, low-cost routes to the chemicals, materials, and fuels that we use today. Markets beyond just power generation will look for technology options to use this energy source more effectively.

Additionally, the ability to store this energy in the form of chemical bonds could create new opportunities, enabling electricity generated by renewable sources to be used hours, months, or even years later.

## How We Get There

NREL is prepared to lead the research on this conversion of electricity and materials such as carbon dioxide and water into high-value chemical precursors. Researchers are developing efficient, electricity-driven processes that transform these readily available and low-cost materials into reactive intermediates and coupling them with biological or catalytic processes to generate compounds that we use today to make plastics, fibers, and fuels.

Besides the conversion of carbon dioxide and water, NREL also will investigate the use of electricity-driven processes to convert other materials such as nitrogen to ammonia, transform fossil fuels and biomass into chemicals, deconstruct plastics for recycling and reuse, and refine ores to generate metals.

## Working Together

These challenges require sensible solutions. Working with industry, government, research, and nonprofit partners, we can achieve them far faster and more efficiently than working on them independently.

NREL is committed to ensuring our research gets to market—where it can improve everyday life and strengthen our economy. We have nearly 900 active agreements with almost 600 partners, over half of which are private-sector companies.

Such partnerships create powerful synergies between NREL's early-stage research and industry's market-focused activities, which will unleash the creativity of both. By transforming our science, we can accelerate the development of new energy technologies through “de-risking” the early-stage research needed to innovate.

Together, we can bridge the gap from concept to market, linking our renewable energy and energy-efficient technologies with strategies to achieve real-world impact.